

The U.S. Department of Energy Initiative on Battery Manufacturing

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***Meeting Global Challenges:
US-German Innovation Policy***

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DOE Vehicle Technologies Program Goals

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Energy Efficiency &
Renewable Energy

Decrease petroleum dependency

Reduce greenhouse gases

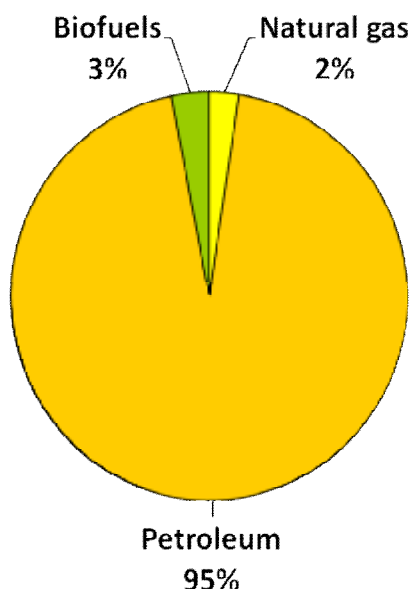
- Develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum
- Develop technologies that provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment



We are Highly Dependent on Oil

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U.S. transportation fuel share (2008)



- Transportation is responsible for 2/3 of our petroleum usage
- On-Road vehicles responsible for ~80% of transportation petroleum usage

U.S. Vehicle Market

- > 240 Million vehicles on the road
- Approximately 11M new cars & light trucks for 2010; average is 15.7 M/yr 2002-2007
- Hybrid vehicles now <3% of sales

New Oil Reserves are Harder to Find

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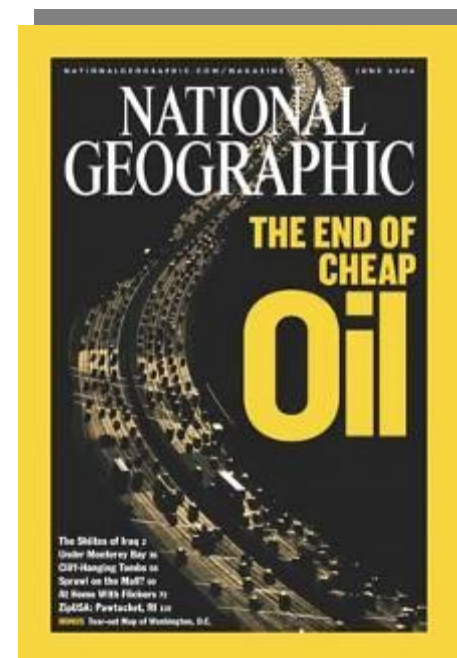
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- Global discovery of new oil fields peaked in 1966.
- U.S. oil *production* peaked in 1971.
- World oil production has hardly grown at all since 2005.

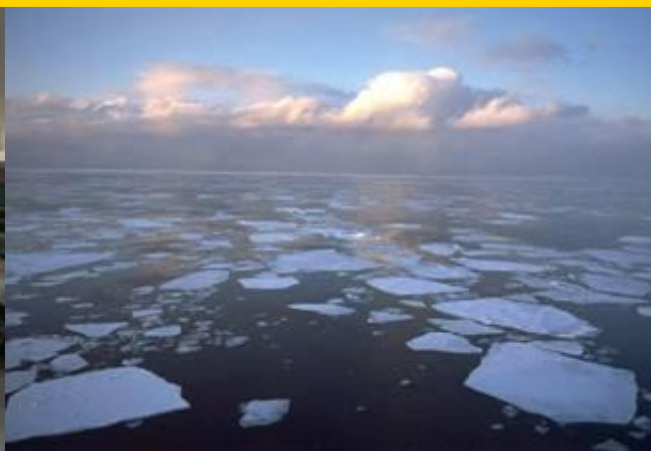
Source: Jeff Rubin, "Why the World is About to Get a Whole Lot Smaller"

World Oil Production

2005: 84.58 mbpd
2006: 84.54 mbpd
2007: 84.40 mbpd
2008: 85.37 mbpd
2009: 84.24 mbpd



The Cost of Oil is More than Monetary



Analysis Informs Strategy

Projected Vehicle Technology for 2030

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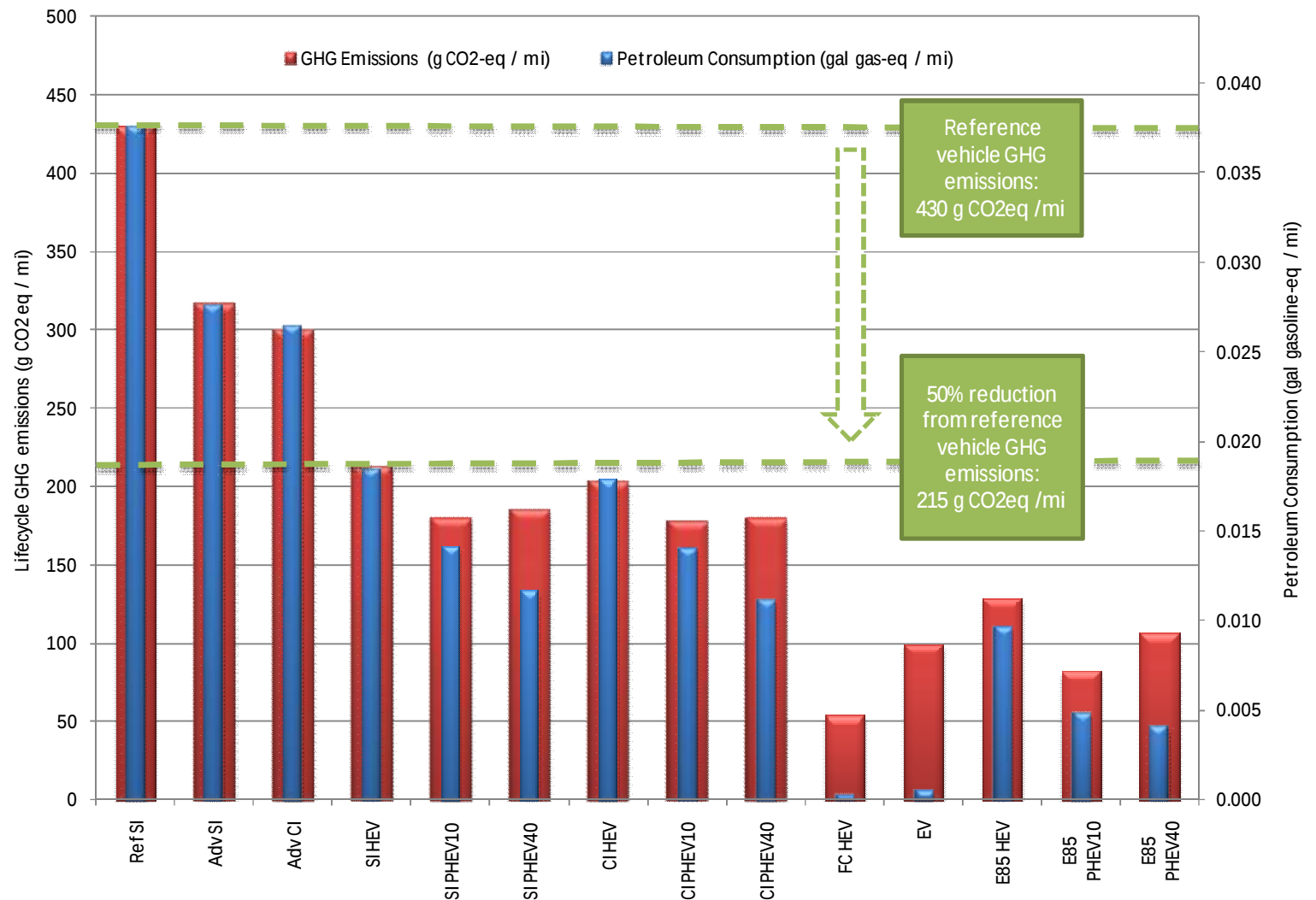
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Vehicle GHG emissions fall into 3 major groups:

- Conventional
- Electric-drive
- Combination electric-drive & biofuel

Petroleum consumption loosely mirrors GHG emissions

GHG Emissions and Petroleum Consumption by Vehicle Technology



Unprecedented Investment in Advanced Vehicle Technologies

- A 50% increase in Vehicle Technologies Program budget in the last 2 years
 - 1/2 of our over \$311M budget directly on vehicle electrification initiatives
- \$25B Advanced Technology Vehicles Mfg Loan Program,
- The launch of ARPA-e
- The Recovery Act's greater than \$2.8B in grants for vehicle technology & demos



Other DOE Vehicle Activities

- VT ARRA Activities \$2.8 B
- ATVM Loan Program \$25.0 B
- Other DOE
 - Office of Science
 - ARPA-E
 - Office of Electricity

Open Questions About Electric Drive

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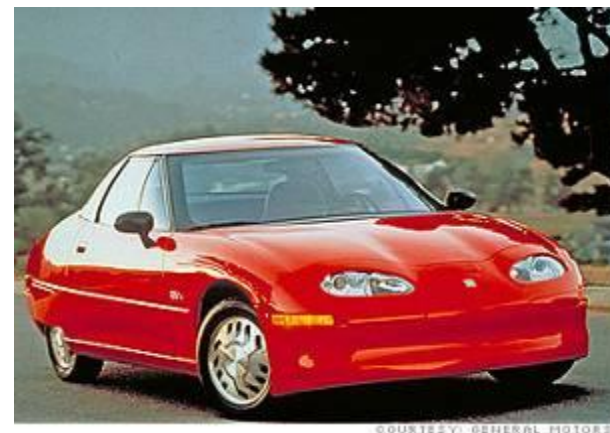
- What's Different This Time
- Grid Capacity
- Battery Cost
- Charging Infrastructure



What's Different This Time

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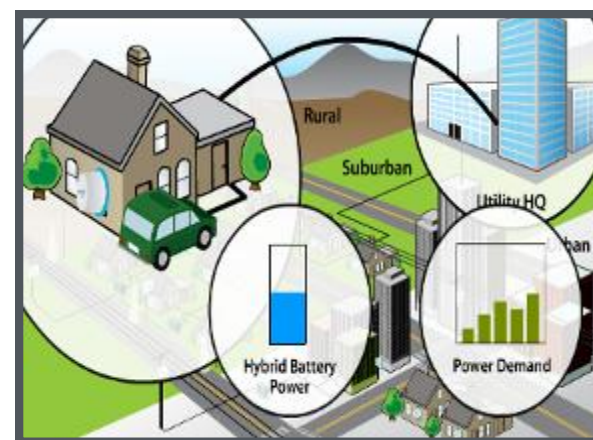


Answer:

- Urgency to Solve Energy and Environmental Challenges
- Battery Technology

Vehicle Electrification: Grid Impacts

- In the U.S., current grid capacity could supply about 70% of our vehicles without adding capacity, but assumes:
 - vehicle would charge only during off-peak
 - “perfect” distribution of electricity
 - No localized affects such as overburdening neighborhood transformers
- EVs and PHEVs will not cause a grid “meltdown,” but we clearly need to work fast as vehicles are rolled out to reduce impacts
- Smart Charging will be key to lowering cost and minimizing impacts
- Time of day pricing also important



Buildout of Charging Infrastructure

- Key today: Home Charging
 - Need to get the cost and installation process right. Currently a significant barrier
- Public Charging
 - Expensive if not well utilized
 - Expansive to fully cover full driving patterns
- Ideally need market pull to determine public infrastructure build-out
 - PHEVs are key to help initiate market pull for public infrastructure



Hybrid-Electric Systems

Petroleum Displacement via Fuel Substitution & Improved Efficiency

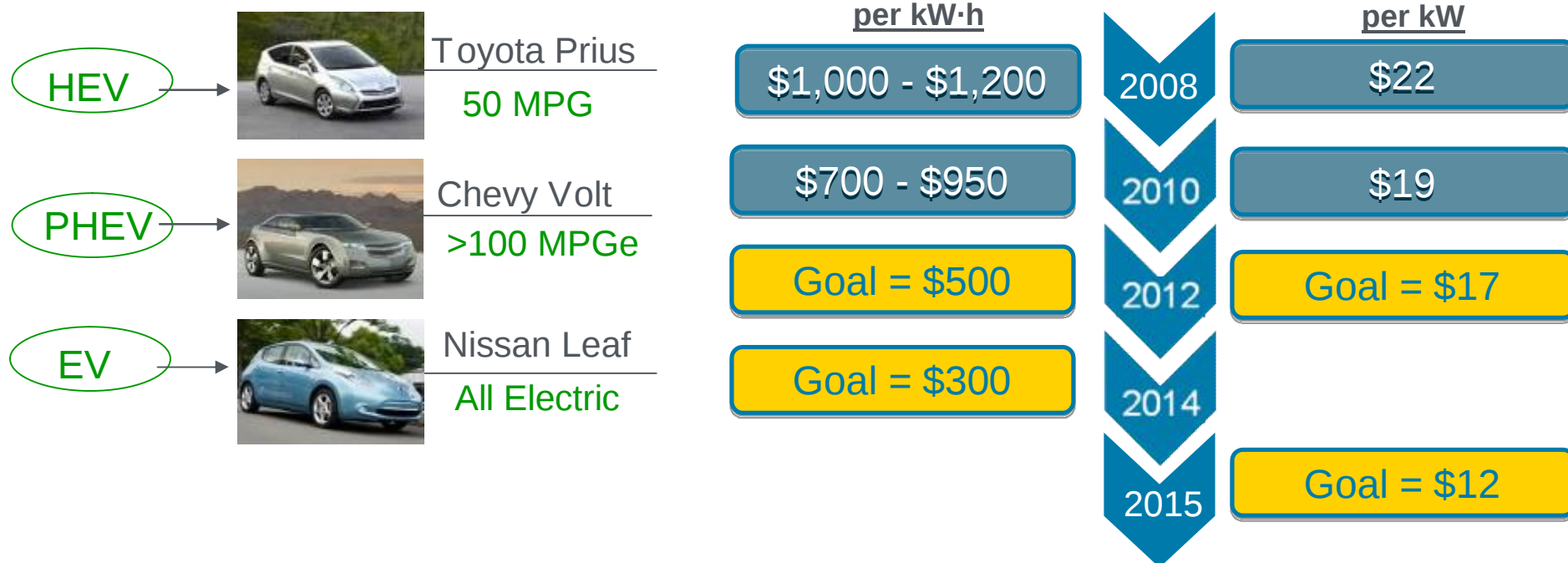
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Administration Goal: 1 Million PHEVs by 2015

Types of Vehicles and Benefits

System Cost



***Cost reduction will occur primarily through improvements
in chemistry – not manufacturing technology***

Recovery Act : \$2.8 Billion

Advanced Vehicle Technology Projects

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\$1.5 Billion in funding to accelerate the manufacturing and deployment of the next generation of U.S. batteries

\$500 Million in funding for electric-drive components manufacturing

\$400 Million in funding for transportation electrification



SuperTruck and Advanced Combustion R&D
\$104.4 Million Solicitation:

Heavy-duty trucks are emphasized because they rapidly adopt new technologies and account for 20% of the fuel consumed in the United States.



Clean Cities: \$300M for Petroleum Displacement through Alternative Fuel Vehicles and Expanded Alternative Fuel Infrastructure



Recovery Act Opportunity Energy Storage Announcement

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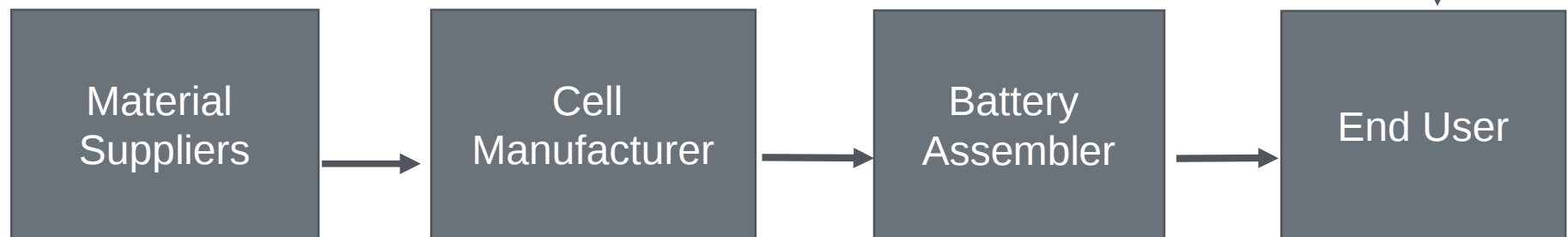
Recovery Act Approach

- FOA strategy
 - Establish a complete “value chain” for lithium battery manufacturing: from material supply, to cell production, to pack assembly
- Seed money to get started
 - 500,000 PEVs/yr = <5% of market
 - Sized to support market growth
- Expect industry to grow



Electric Drive
Component

Integrated Supply Chain



Battery Market Values



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- **Lithium battery market worldwide currently:**
 - \$8 billion* (2009), largely consumer electronics applications
- **Hybrid vehicle battery market worldwide currently:**
 - largely nickel metal hydride
 - ~500,000 HEVs/yr @ ~\$3,000 each ==> ~\$1.5 billion
- **Market estimates for automotive lithium batteries (worldwide)**
 - 2015: ~800,000 EVs/yr** @ ~\$10,000 each ==> ~\$8 billion
 - 2020: ~6,000,000 EVs/yr** @ ~\$5,000 each ==> ~\$30 billion

* H. Takeshita, 26th International Battery Seminar, Ft Lauderdale, FL, March 2009

** Roland Berger, 2010; Pike Research, 2010

Recovery Act Battery Events

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President Obama at Compact Power



Secretary Chu at General Motors



President Obama at Celgard



**Vice-President Biden at
Dow Kokam**



**Governor Granholm at
Toda America**

Battery Manufacturing Facilities

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Company	Location	Total Investment	Cell Manu.	Pack Assembly	Description
	Holland, MI Lebanon, OR	\$600 M	✓	✓	Li-Ion: Nickel Metal Cobalt
	Romulus & Brownstown, MI	\$500 M	✓	✓	Li-Ion: Iron Phosphate
	St. Clair & Holland, MI	\$390 M	✓		Li-Ion: Mixed Manganese
	Brownstown, MI	\$236 M		✓	
	Jacksonville, FL	\$191 M	✓	✓	Li-Ion: Nickel Metal Cobalt
	Midland, MI	\$490 M	✓	✓	Manganese Spinel
	Bristol, TN & Columbus, GA	\$70 M	✓	✓	Spiral Wound AGM and Flat Plate Batteries
	Lyon Station, PA	\$98 M	✓	✓	Advanced VRLA and the Ultra Batteries
	Indianapolis, IN	\$180 M	✓	✓	Li-Ion: Nickel Metal Cobalt

Battery Materials, Production and Recycling

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Company	Location	Funding	Material	Description
 BASF The Chemical Company	Elyria, OH	\$50 M	Cathode	Production of nickel-cobalt-metal cathode material for Li-ion batteries
	Goose Creek, SC	\$70 M	Cathode	Production of nickel-cobalt-metal cathode material for Li-ion batteries
	Sanborn, NY	\$23 M	Anode	Production of carbon powder anode material for Li-ion batteries
	Batesville, AR	\$25 M	Anode	Production of high-temp anode material for Li-ion batteries
	Zachary, LA	\$41 M	Electrolyte	Production of electrolytes for Li-ion batteries
	Buffalo, NY & Metropolis, IL	\$55 M	Electrolyte	Production of electrolyte salt for Li-ion batteries
	Charlotte, NC & Aiken, SC	\$101 M	Separator	Production of polymer separator material for lithium-ion batteries
	Silverpeak, NV & Kings Mtn., NC	\$60 M	Lithium	Production of battery-grade lithium carbonate and lithium hydroxide
	Albany, OR	\$28 M	Carbon	Production of high-energy density nano-carbon for ultracapacitors
	Holland, MI	\$10 M	Cell Casing	Manufacturing of precision aluminum casings for cylindrical cells
	Lancaster, OH	\$19 M	Recycling	Hydrothermal recycling of Li-ion batteries
	Lebanon, OR	\$26 M	Separator	Production of battery separators for HEVs and EVs

Electric Drive Vehicle Components



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Company	Location	Funding (DOE / Total)	Description
	Anderson, IN	\$60 M / \$120 M	Motor and Inverter Manufacturing
	Kokomo, IN	\$89 M / \$179 M	Inverter, Converter, and Controller Manufacturing
	Indianapolis, IN	\$63 M / \$126 M	Production of Commercial Truck Hybrid Systems
	Sterling Heights, MI	\$63 M / \$125 M	Production of HEV and PHEV Transaxles
	Simpsonville, SC	\$15 M / \$32 M	DC Bus Capacitor Manufacturing
	Frederick, CO	\$45 M / \$90 M	Electric Propulsion System Manufacturing
	Barre, VT	\$9 M / \$18 M	DC Bus Capacitor Manufacturing
	Youngwood, PA	\$6 M / \$9 M	Electric Drive Semiconductor Manufacturing
	Holly, MI; Muncie, IN	\$40 M / \$87 M	Inverter, Converter, Controller, Charger, and Electric Drive System Manufacturing
	White Marsh, MD; Wixom, MI	\$105 M / \$246 M	Electric Drive Motor and Unit Manufacturing

Transportation Electrification Demonstration Projects

- **8 Grants representing the largest ever coordinated deployment of electric-drive vehicles and charging infrastructure in the U.S.**
 - Deployment of **7,000 electric-drive vehicles**, including light-duty, medium-duty, and heavy-duty passenger and commercial vehicles in a variety of climatic and operating environments
 - Installation of over 20,000 Level 2 (240VAC) vehicle charging sites at residential, commercial, and public locations and 350 Level 3 (500VDC) Fast Chargers
 - Collection of detailed operational data from vehicles and charging infrastructure, to evaluate and analyze vehicle usage, charging patterns, and potential grid impacts in preparation for broader, long-term deployment of vehicles and infrastructure



- **10 Grants to establish comprehensive educational and outreach programs focused on electric-drive vehicles**
 - Funding of the first programs to educate first responders and emergency personnel in how to deal with accidents involving EVs and PHEVs

American Reinvestment and Recovery Act Smart Grid Investment Grants

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(100 projects: \$3.4B Federal; \$4.7B non-Federal)

Smart Grid Systems and Equipment	Numbers of Units (self-reported estimates)	Improvements
Smart Meters	18,179,912	• 13% of the 142 million customers in the U.S.
Load Control Devices	176,814	• Enables peak demand reductions
PHEVs / Charging Stations	12 / 100	• Accelerates market entry
Smart Transformers	205,983	• Enables preventative maintenance
Automated Substations	671	• 5% of 12,466 transmission and distribution substations in the U.S.



Contact Information

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Building the Electric Vehicle Industry

Panel Moderator: Kevin Hurst, Ph.D.

Office of Science and Technology Policy
Executive Office of the President

November 1, 2010

Presidential Priorities

- Protect our nation from the serious economic and strategic risks associated with our reliance on foreign oil and the destabilizing effects of a changing climate.
- Advance energy and climate security via promoting economic recovery efforts, accelerating job creation, and driving clean energy manufacturing.
- Commitment to comprehensive energy-climate policies that will:
 - o reduce dependence on foreign oil;
 - o improve air & water quality;
 - o cut back the carbon pollution that is changing the climate;
 - o create new American jobs around the clean, domestic energy sources that will get all this done.



The American Innovation Strategy

- **Invest in the building blocks of innovation**
 - restore leadership in fundamental research
 - boost STEM education
 - strengthen physical infrastructure
 - develop an advanced IT “ecosystem”
- **Promote competitive markets to spur innovation**
 - support capital markets that fund innovation
 - encourage innovation□based entrepreneurship
 - boost public□sector & community innovation
 - promote American exports
- **Catalyze breakthroughs for national priorities**
 - **unleash a clean□energy revolution**
 - **support advanced□vehicle technology**
 - drive breakthroughs in health IT
 - address other “grand challenges” of the 21st century

The Administration has made an unprecedented investment in advanced vehicle technologies

- Recovery Act
 - \$2.8B in grants for EV technology and demonstrations.
 - \$7500 per-vehicle tax credit for EVs and PHEVs.
 - \$4.5B for Smart Grid infrastructure.
- \$25B for the Advanced Technology Vehicles Manufacturing Loan Program.
- Funding for the DOE Vehicle Technologies R&D Program increased by 50% from FY2008 to FY2010.
- DOE's Vehicle Technologies R&D (\$311M in FY 2010) is focused heavily on vehicle electrification initiatives.
- ARPA-E: Batteries for Electrical Energy Storage in Transportation
- New CAFE standards

Next-Generation EV Research

- DOE Vehicle Technologies Program
- Basic research at DOE Office of Science, NSF, DOD
- ARPA-E
- Innovation Hub on Energy Storage R&D (proposed)

Harnessing private innovation: prizes and challenges

- Prizes & challenges harness the ingenuity that lurks in individuals, schools, firms all across society. Sponsors/organizers set an ambitious goal without prescribing the best means to achieve it, and pay only for results.
- The Administration's new challenge.gov website provides 1st stop shopping for innovators looking for opportunities.
- The recent Progressive Insurance / DOE Automotive X²Prize illustrates the leverage in this approach.
 - \$10M in prizes for super²fuel²efficient passenger vehicles (over 100 miles per gallon of gasoline equivalent) called forth \$100M+ in investments in innovation by competitors.
 - Winning designs achieved up to 200 MPGe.



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Policy questions

1. How can US-German and US-EU collaboration help enable the technical and market success of EVs?
2. How important is an energy storage “revolution” (at the device-level or system-level) to the growth of the EV industry?
3. Which government policy tools will be most important to building the EV industry over the next five years?
4. What should be the top priorities for electric utilities and State PUCs to prepare for wide-scale deployment of EVs?
5. Is government involvement needed to accelerate technical standards for EVs and EV infrastructure?